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CONCEPTS FOR UTILIZATION OF VIDEO DISCS IN MILITARY APPLICATION--ETC(U)
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Concepts for Utilization of Video Discs in Military Applications

M. J. McKELVY

APRIL 1977

MITRE

MITRE Technical Report

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MITRE Project Approval: Walter Yondorf

ABSTRACT

Video disc systems, an emerging technology, offers great potential in several military application areas. These systems can be used for training and teaching, for document mass storage and retrieval, or for digital data storage and retrieval. This paper reviews the current state of video disc technology and compares video disc capabilities to these and other storage media, and describes concepts for utilizing video disc systems in military applications.

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EXECUTIVE SUMMARY

Each year vast amounts of money and other resources are expended by the military in collecting information. Large sums of money and human resources are also spent in organizing, analyzing, and preparing this information for operational users. State-of-the-art automated systems as well as traditional manual systems are used to store, retrieve, and display this information for operational users. Still many military application areas suffer from the lack of timely appropriate information, displayed in a form best suited to the human decision-makers. To decision-makers, information is power. In our increasingly complex technological society, especially in the military community, increasing quantities of information in many forms (e.g., graphics, textual, digital, photographs, etc.) are required to make informed critical decisions.

An emerging technology, video disc systems, offers great potential in many application areas. Several companies are pursuing some aspect of this technology--primarily for use in the consumer home entertainment or commercial markets. While different recording and playback techniques are being developed, it appears that video disc systems which utilize lasers for recording and have optical playback systems are most appropriate for military applications. To represent the capabilities of such systems, considerable information about the offerings of two United States vendors, MCA Inc. and I/O Metric Corporation, is presented in this report. Specifically, the systems can play back information on a 12-inch disc (resembling an LP record) to provide:

(1) Up to 40 billion bits of digital information per disc side, or

(2) Up to 30 minutes of NTSC video (motion pictures) per disc side, or

(3) Up to 54,000 video still frames of documentation; e.g., books, maps, photos, etc. per disc side,

(4) Access to any specific frame (by frame number) of the 54,000 frames on a disc in about 15 second maximum (could be reduced to 1 second or less), and

(5) Stereo sound (or up to four tracks) for the video program.

Thus, the systems could be used for document mass storage; in teaching machine applications; for training with freeze motion, fast forward, fast reverse, specific frame access, etc.; and, for read only computer digital storage.

A player (18" x 18" x 8-1/2" and weighing less than 40 pounds) when attached to a standard television can be used to view pictorial information, documents, etc. One cubic foot of discs (three hundred one-sided 12" diameter discs) can contain over 16 million television frames (or about 5 million printed pages of documentation) and the user can gain access to any specific frame within seconds. A single disc side could contain all volumes of the Encyclopedia Britannica. In addition, a single disc can contain up to 40 billion bits of information for computer use. Motion pictures in color with stereo sound as well as still frame images may be recorded on the discs. Combinations of motion pictures, still frame information, and digital data may all be recorded on a single disc.

This technology has potentially great advantages in handling, storage, and retrieval of many types of information. The cost of replicated copies and the user playback equipment are significantly less expensive than other currently available alternative means. Also, the replication rates are far in excess of the other means now available. However, in most cases the cost of collecting the information (e.g., flying reconnaissance missions), preparing the information (e.g., annotating terrain photographs), and other human intensive processes will continue to be the majority of the total information costs. The effectiveness and utility of these devices promises to be very high--if the applications for which they are employed are carefully selected. Accordingly, it is felt that the Army should obtain experience with this technology and its applicability to military problems.

It is expected that video disc technology and equipment capability will experience considerable growth over the next several years as the manufacturers compete for positions--primarily in the home entertainment market and secondarily in military/industrial markets. Accordingly, if the Army chooses to invest R&D funds in this technology, it seems advisable to direct funded efforts at determining and exploiting the potential utility of video discs for military applications rather than at advancing the basic video disc technology. Three types of applications are explored in this report: a 3-D battlefield display; an improvement to the Analytical Photogrammetric Positioning System (APPS); and a mobile military reference library. It is suggested that a demonstration program would serve to gain practical experience with this technology and to acquaint the Army with its potential.

As an example, a demonstration of the 3-D battlefield display could be developed in a fashion which would incorporate several

features of the other two applications discussed in this report. Video discs would have the capability to store and rapidly retrieve the terrain images for display by video projection systems. Three-dimensional projection techniques from film and video tapes have been demonstrated previously. However, a 3-D demonstration using video disc would afford the Army an opportunity to evaluate the operational steps of converting source material to video discs and provide first-hand experience relevant to a number of other military applications. The total duration of the experimentation program would be about six months and the cost would be between $100K and $200K. Demonstrations could take place in late 1977 or early 1978.

1.0 PURPOSE

Video discs have been primarily targeted for the home consumer market for entertainment purposes (e.g., movies). The video players are designed to connect into the antenna terminals of a standard black and white or color television receiver. The discs resemble hi-fi long-playing records and provide 30 minutes of color television programming. Recently, the manufacturers have begun to emphasize the use of this technology for electronic documentation, digital data storage for computers, and education and training applications. Thus, the industrial and military applications of this technology are gaining visibility.

The purpose of this paper is to portray the current state of video disc technology and to explore concepts for its utilization in military applications. Three applications are considered: an Army Three-Dimensional Battlefield Display System, an Automated Analytical Photogrammetric Positioning System (APPS), and a Mobile Military Library. A demonstration and experimentation program is suggested in order to gain first-hand experience with this potentially revolutionary technology.

2.0 APPLICABILITY OF VIDEO DISC SYSTEMS TO SPECIFIC PROBLEMS

This paper considers only the video disc systems utilizing optic techniques in recording and playback. The reasons for this restriction are discussed in paragraph 4.0. Table I contrasts information storage, retrieval, and display problems with relevant video disc systems capabilities to show the applicability of video disc systems to many Army problems.

TABLE I

APPLICABILITY OF VIDEO DISC SYSTEMS

PROBLEM AREA	VIDEO DISC SYSTEM CAPABILITIES
1. Provide rapid and simultaneous access to an orthophoto and its stereo mate for Three-Dimensional Display - See paragraph 5.0 for additional details. 2. Provide storage and rapid retrieval for documentation such as maps, plans, procedures, photographs, field manuals, etc. which consist of thousands of pages and consume valuable command post space and whose manual retrieval is both difficult and time consuming. 3. Provide storage and rapid retrieval of archival and historical documentation, e.g., old reconnaissance photos of enemy installations, enemy situation reports, etc. 4. Provide better storage and retrieval of computer output than provided currently by Computer Output Microfilm techniques.	Mass Storage and Rapid Retrieval of Visual Images - A video disc (one side) can store 54,000 video frames in color. Each frame is individually identified and can be retrieved for viewing by its frame number. Thus, a single side of a 12-inch disc (0.04 inches or less thick) could contain all volumes of the Encyclopedia Britannica and the user could gain access to any specific page within a maximum of 15 seconds (could be reduced to 1 second or less). - Video disc replication and material cost are substantially less than video tapes or film. Replication is also much faster. Handling of discs is easier than handling tapes or film. Also, video discs require substantially less space than video tapes or even microfilm. Computer output microfilm requires only 1% of the storage space of computer printout and computer output video discs require only 1/14 as much space as microfilm.

TABLE I (cont.)

PROBLEM AREA	VIDEO DISC SYSTEM CAPABILITIES
5. Provide storage and rapid retrieval for background graphics (e.g., maps) for computer graphic displays. Computer graphics consume large amounts of valuable command post computer resources.	- Section 3.0 describes how video discs would be used for computer graphic backgrounds to reduce computer loading.
6. Provide an efficient means of providing training and informational materials to military students.	*Color Motion Pictures* - Traditional training films, demonstrations, operations of military weapons systems, etc. can be presented on video disc in color with up to four NATO language sound tracks. Again, many handling and cost advantages are possible. Each disc side typically contains 30 minutes of color program material and stereo sound.
7. Provide mass read only digital storage for command post computers; e.g., to store programs, historical or reference data, directories, data element dictionaries, etc.	Digital Read Only Storage - A single disc side can contain up to 40 billion bits of digital information which can be read back at a rate of 30 million bits per second. Thus, many computer tapes or standard magnetic discs can be recorded on a single video disc. Replication costs for static files, or programs to be widely distributed would be minimal.

TABLE I (concluded)

PROBLEM AREA	VIDEO DISC SYSTEM CAPABILITIES
8. Provide interactive teaching, simulators, etc. which require combinations of large volumes of visual materials, sound, motion, digital information, and computer interface for branching and control of information presentation based on user responses and commands.	Hybrid Discs - When the video discs systems are interfaced with computers, hybrid video discs containing visual material (e.g., maps, photos, books, etc.) and digital information (e.g., answers to test questions, programs, etc.) can be used to create interactive teaching machines, realistic helicopter flight planning simulators, etc.

3.0 CONCEPT FOR UTILIZATION OF VIDEO DISC SYSTEMS IN MILITARY APPLICATIONS

Figure 1 illustrates a configuration of a C^3I (Command, Control, Communication and Intelligence) System. The video changers Number One and Two are associated with a 3-D Terrain Display which is discussed in greater detail in Section 5.0. The orthophotos (for all scales shown in Table VIII) are contained on the video player/changer Number One, and their mates are contained on player/changer Number Two. A corresponding orthophoto and its mate are selected under the control of the computer or by an operator. For example, the operator may designate the MGR (Military Grid Reference) and scale he wishes to view. The computer determines the appropriate discs to be selected and the number of the frames on those discs which contain desired terrain information. The computer then controls the selection process. Projection system Number One projects the orthophoto and Number Three projects its mate; thus, producing a 3-D terrain image. Projection system Number Two would project superimposed computer generated symbols such as targets, radars, or bridges onto the view. The operator could make slight adjustments of alignments using annotated grid lines, or adjust focus, etc. An optical automatic alignment system could also be used. In some cases, the operator may add symbols (e.g., bridges) to the computer's digital data base (stored on the computer's magnetic disc). The system's information from sensors, operator inputs, etc. is initially processed and stored on the computer's disc. Sensor information may also be filtered and displayed as symbols on the large screen immediately.

The operator would control what area and scale is to be shown. The computer would determine what information in its digital data base belongs in the selected geographic area and display it. The operator using annotated grid lines on the photos, and a computer-generated cursor, could indicate video grid alignment to the computer

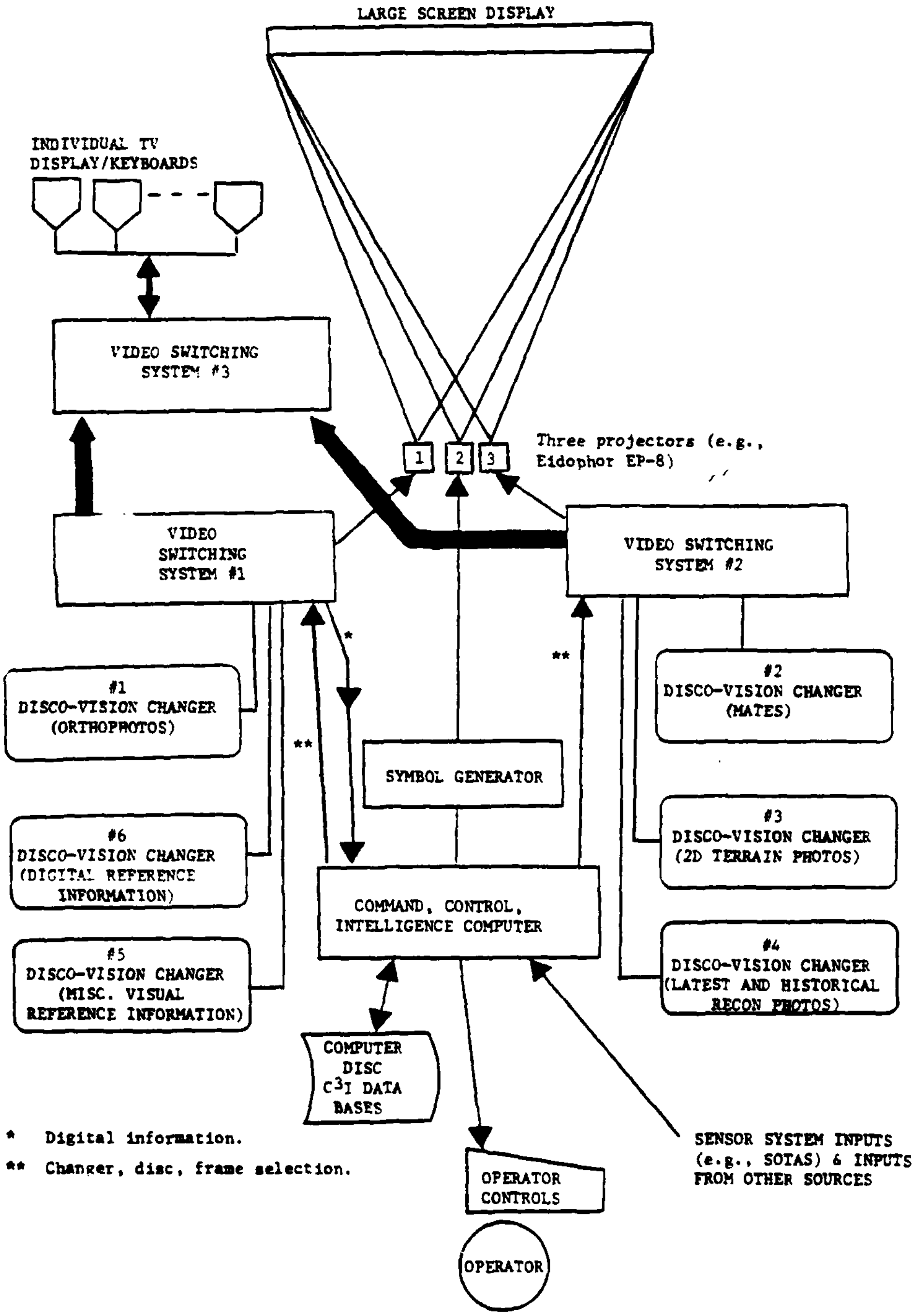

FIGURE 1
BLOCK DIAGRAM OF 3-D BATTLEFIELD DISPLAY SYSTEM

so that the computer symbols are generated in the proper location. The scale of the symbols would be selected by the computer to be the most appropriate feasible for the scale being viewed.

Since the access time to any frame on any disc is short (a few seconds), an effective terrain zoom capability is provided. For example, initially a 40 km by 30 km terrain scene or map may be viewed and then the operator could select a specific area to be viewed at a 1/3 by 1/4 km scale. To do this, he would merely insert the MGR and scale desired on his computer terminal keyboard and the computer would direct the video disc system to the appropriate frames. Section 6.0 describes utilization of video discs to increase the speed and accuracy of target coordinate production using the APPS terrain photos.

Other uses of video discs are also shown in Figure 1. Since analysts do not always need 3-D and may not always desire to wear the required spectacles, player/changer Number Three could contain standard two-dimensional terrain photos. Player/changer Number Four could contain the latest and important historical reconnaissance photos; this would assist command personnel in accomplishing such tasks as evaluating enemy progress in building airfields, assessing damage, etc.

Player/changer Number Five could provide a variety of other visual information; e.g., maps of various scales, documented operational procedures, computer output of relatively static files, such as certain intelligence files (e.g., installations, enemy and friendly weapon reference data, command structure, etc.), personnel files, logistic files, etc. If ten discs are mounted in the changer, then 540,000 frames of information would be available on the ten discs. Discs can be individually added to or taken off the player/changer.

Player/changer Number Six could contain seldom used but important archival digital data for the computer. Ten discs could contain up to 400 billion bits of data. These discs could contain a large library of computer programs, reference data, etc.

Video switch system Number Three is used to provide computer access or video disc imagery to a number of command post staff positions. The individual TV displays at these positions would be limited to two-dimensional information; alternatively a more complex system, as the one discussed in paragraph 5.3.3, could be employed.

Off-line players could be used to study reconnaissance photographs, access off-line documentation, etc. A hardened militarized version of the player could be thrown in the back of a jeep and taken to the front line. A cubic foot of discs (about 300 discs) could provide over sixteen million video frames of documentation, maps, field manuals, code books, photographs of enemy weapons, and other useful visual materials. An index at the beginning of each disc would allow the user to access any specific information within seconds. See Section 7.0 for a discussion of a mobile military library.

4.0 DESCRIPTION OF VIDEO DISC SYSTEMS

The objective of this report is to indicate the potential benefits of using video disc systems. Tables II through VII compare video disc systems with other media. This paper considers only video disc systems using optical techniques (specifically the MCA and I/O Metrics systems) because of their apparent advantages in long disc life and freeze frame capabilities (necessary for document storage and retrieval). Magnetic media or capacitive pickup (stylus in groove) systems seem less appropriate at this point in time. Video tapes have many serious disadvantages, especially degradation in quality when a frame is repeatedly read and the relatively long sequential search times to locate a specific frame. In addition, tape handling, danger of errasure by magnetic forces (e.g., power transformers), frame by frame recording, and identity of each frame make video tapes less than ideal for use in a military system.

A good view of the range of capabilities, techniques, and costs of optics-based video disc systems can be obtained by reviewing the products of MCA, Inc. and I/O Metric Corporation. Thomas-CSF, a French firm, has a similar system in an advanced stage of development. Zenith, RCA, and a number of other companies are also becoming active in optical video disc systems. See Reference 3 for a review of these corporate efforts.

Paragraph 4.1 of this paper describes the MCA DISCO-VISION system. MCA and N. V. PHILIPS' GLOEILAMPENFABRIEKEN of Europe have each had their own video disc systems in active development for a number of years. Now they have entered into a long-term agreement to join efforts. The first demonstration by both MCA and Philips of a color program over a home TV using this technology was in late 1972. At present, Philips and MCA plan to introduce Philips NTSC players (manufactured by Magnavox in the U.S.) and MCA discs on a regional basis

TABLE II

COMPARISON OF VIDEO DISCS WITH OTHER MEDIA - CAPACITY

MEDIA	REQUIREMENTS FOR 54,000 IMAGES	REQUIREMENTS FOR 40 BILLION BITS
VIDEO TAPE (3/4" COLOR)	1125 FT.*	
SUPER 8MM FILM	750 FT.**	
VIDEO DISC (ANALOG)	ONE DISC (0.04" X 12" DIA.)	
VIDEO DISC (DIGITAL)		ONE DISC (0.04" X 12" DIA.)
COMPUTER TAPE 2400 FT. 1600 BPI, CONTINUOUS		108.5 REELS OF TAPE
COMPUTER TAPE 2400 FT. 1600 BPI, 128 BYTE RECORDS, EOR GAP = 1/2"		786 REELS OF TAPES
COMPUTER TAPE 2400 FT. 800 BPI, 128 BYTE RECORDS, EOR GAP = 1/2"		895 REELS OF TAPES
COMPUTER DISCS (IBM 3330, MOD II)		25 DISC PACKS

* 7 1/2 inches per second tape speed, 30 minutes, 30 frame/sec.
** 50 minutes playing time at 18 frames per second.
37.5 minutes playing time at 24 frames per second.

TABLE III

COMPARISON OF VIDEO DISCS WITH OTHER MEDIA - COSTS (REPLICATION)

MEDIA	CAPACITY AND/OR PLAYING TIME	COST OF MATERIAL (MASTER)	COST OF MATERIAL COPY	UNIT REPLICATION COST (BASED ON RUN OF 10,000 COPIES)
VIDEO TAPE (3/4" COLOR)	54,000 FRAMES OR 30 MIN.	$15		$15
SUPER 8 MM FILM	32,400 FRAMES OR 30 MIN.*	$40 TO $57		$14 TO $18
VIDEO DISC (ANALOG)	54,000 FRAMES OR 30 MIN.	$2.50 TO $1000	$0.08 TO $2.50	$0.10 TO $0.60
VIDEO DISC (DIGITAL)	40 BILLION BITS PER DISC	$2.50 TO $1000	$0.08 TO $2.50	$0.10 TO $0.60
COMPUTER TAPE 2400 FT, 1600 BPI CONTINUOUS	368 MILLION BITS PER TAPE	$12	$12	MATERIAL COST PLUS COMPUTER TIME (10 MIN. ON IBM 370)
COMPUTER TAPE 2400 FT, 1600 BPI, 128 BYTE RECORDS EOR GAP = 1/2 "	51 MILLION BITS PER TAPE	$12	$12	MATERIAL COST PLUS COMPUTER TIME (10 MIN ON IBM 370)
COMPUTER TAPE 2400 FT, 800 BPI, 128 BYTE RECORDS EOR GAP = 1/2 "	45 MILLION BITS PER TAPE	$12	$12	MATERIAL COST PLUS COMPUTER TIME (10 MIN ON IBM 370)
COMPUTER DISC (IBM 3330 MOD II)	1.6 BILLION BITS PER DISC	$350	$350	MATERIAL COST PLUS COMPUTER TIME (10 MIN ON IBM 370)

*At 18 frames per second.

TABLE IV

COMPARISON OF VIDEO DISCS WITH OTHER MEDIA - COSTS (HARDWARE)

MEDIA	MASTERING (RECORDING) UNIT	REPLICATION UNIT	PLAYBACK UNIT	COMBINATION RECORD/PLAYBACK (REAL TIME)
VIDEO TAPE	FEW HUNDRED TO $60,000	SAME	SAME	SAME
SUPER 8 MM FILM	FEW HUNDRED TO FEW THOUSAND	SAME	SAME	NOT AVAILABLE
VIDEO DISCS	$60,000 PURCHASE TO $400K/YR LEASE	$7,500 PURCHASE TO $400K/YR LEASE	$5,000 PUR-CHASE TO $27,000 LEASE	REAL POSSIBILITY $60,000 PURCHASE
COMPUTER TAPE	$12K TO $25K (IBM 3420) PLUS COMPUTER	SAME	SAME	YES
COMPUTER DISCS	$47K (IBM 3330) PLUS COMPUTER	SAME	SAME	YES

TABLE V

COMPARISON OF VIDEO DISCS WITH OTHER MEDIA - REPLICATION RATES

MEDIA	CAPACITY AND/OR PLAYING TIME	COPYING TIME	REPLICATION RATIO (OR RATE)
VIDEO TAPE (3/4" COLOR)	54,000 FRAMES OR 30 MINUTES	30 MINUTES	1:1
SUPER 8 MM FILM	32,400 FRAMES OR 30 MINUTES*	5 MINUTES	6:1
VIDEO DISC (ANALOG)	54,000 FRAMES OR 30 MINUTES	3 SECONDS TO 20 SECONDS	600:1 TO 90:1
VIDEO DISC (DIGITAL)	40 BILLION BITS	3 SECONDS TO 20 SECONDS	13.3 BILLION BITS PER SECOND TO 2 BILLION PER SECOND
COMPUTER TAPE - 2400 FT, 1600 BPI, CONTINUOUS	368 MILLION BITS	10 MINUTES (IBM 370)	613.3 THOUSAND BITS PER SECOND
COMPUTER TAPE - 2400 FT, 1600 BPI, 128 BYTE RECORDS EOR GAP = 1/2"	51 MILLION BITS	10 MINUTES (IBM 370)	85 THOUSAND BITS PER SECOND
COMPUTER TAPE 2400 FT, 800 BPI, 128 BYTE RECORDS EOR GAP = 1/2"	45 MILLION BITS	10 MINUTES (IBM 370)	75 THOUSAND BITS PER SECOND
COMPUTER DISC (3330 MOD II)	1.6 BILLION BITS	10 MINUTES (IBM 370)	2.7 MILLION BITS PER SECOND

*At 18 frames per second.

TABLE VI

COMPARISON OF VIDEO DISCS WITH OTHER MEDIA - ACCESS

MEDIA	ACCESS	SPEED OF SEARCH	CAPACITY OR PLAYING TIME
VIDEO TAPE	SEQUENTIAL	527 FRAMES/SECOND (AMPEX VIDEO FILE)	54,000 FRAMES OR 30 MINUTES
SUPER 8 MM FILM	SEQUENTIAL	LESS THAN 100 FRAMES/SECOND (4X NORMAL)	32,400 FRAMES OR 30 MINUTES*
MICROFICHE	RANDOM	A FEW SECONDS	100 IMAGES PER MICROFICHE CARD
VIDEO DISC (ANALOG)	RANDOM	3600 FRAMES/SEC** 216,000FRAMES/SEC***	54,000 FRAMES OR 30 MINUTES
VIDEO DISC (DIGITAL)	RANDOM	2.67 BILLION BITS/SEC** 160 BILLION BITS/ SEC***	40 BILLION BITS
COMPUTER TAPE 2400 FT, 1600 BPI, CONTINUOUS	SEQUENTIAL	960K BITS/SEC (75 IPS - IBM 3420)	368 MILLION BITS
COMPUTER DISC (IBM 3330)	RANDOM	29 BILLION BITS/SEC. (30 MS. AVG. - 55 MS MAX. - IBM 3330)	1.6 BILLION BITS (IBM 3330 MOD II)

*At 18 frames per second.
**15 sec, max. (now).
***0.25 sec, max. (future).

TABLE VII

COMPARISON OF VIDEO DISCS WITH OTHER MEDIA--HANDLING/STORAGE

MEDIA	REQUIRED TO EQUAL ONE VIDEO DISC	HAZARDS/OTHER
VIDEO TAPE (3/4" COLOR)	1200 FEET	1. USE 2. MAGNETIC FIELDS
SUPER 8 MM FILM	750 FEET (54,000 FRAMES)	1. USE 2. FIRE (FREEZE FRAME)
COMPUTER TAPES (2400 FT EACH)	108 TO OVER 900 DEPENDING ON RECORD LENGTH AND DENSITY	MAGNETIC FIELDS
COMPUTER DISCS (IBM 3330)	25	MAGNETIC FIELDS
MICROFICHE (100 IMAGES PER CARD)	540	

in 1978. No doubt one of MCA's strong advantages in the home consumer market is its reservoir of more than 11,000 film titles available for programming through the Universal Film Library (a subsidiary). Also, MCA plans to use Universal Studios to produce a variety of new, original programming especially tailored to consumers.

Paragraph 4.2 describes the I/O Metrics System. While MCA, with its huge corporate resources, seems to be targeted at all markets with emphasis on the home consumer market, I/O Metrics, a relatively small company, is targeted primarily at industry, government, and educational markets. I/O Metrics has placed heavy emphasis on achieving low cost for low volume disc runs (i.e., only a few copies).

4.1 The Philips-MCA DISCO-VISION

MCA has recognized many industrial (e.g., education, retail, etc.) and government uses for its DISCO-VISION and has created a special organization to handle this market. One classified government agency has acquired two players. Also, several demonstrations have been made to industry, the press, and the military.

A single 12-inch disc (resembling a long playing hi-fi record) can contain all volumes of the Encyclopedia Britannica, and any of the 54,000 video frames per disc side can be selected within seconds for continuous viewing. A user disc is only 0.04 inches thick and recording is only on one side; however, two discs could be joined to form a two-sided disc about 0.1 inch thick.

Besides home consumer sales, MCA has identified a number of other applications: e.g., library, catalog, and archival storage; education including a teaching machine with branching; medical; credit card verification; law enforcement storage of fingerprint cards and mug shots; point of purchase displays; electronic documentation; and many other applications.

A number of military applications have been identified. One application of particular interest is to replace computer output microfilm with computer output discs. MCA claims computer output discs have cost advantages over computer output microfilm. For example, a microfilm of computer output reduces physical storage space to about 1% of the need for an equivalent number of printed pages. Video discs reduce the space required to 0.07% of that for printed pages, or a fourteenfold advantage over microfilm. Thus, computer output discs could be used for relatively static data bases which require wide distribution. For example, a massive enemy installation file, containing data on enemy airfields and installations, could be processed on computer output discs. Consumer discs are designed to sell for $2 to $10 each. MCA indicates that in volume lots, the replication cost is only about 60 cents per disc side. For a computer output disc, MCA estimates cost for 100 copies will be about 45 cents per 1,000 pages of source. If 500 copies are required, the disc cost falls to 8.4 cents per 1,000 pages.

The MCA DISCO-VISION records audio and video information on a master disc. The master is then used to make "stamper" discs which are used in turn to replicate the disc as plastic copies, and these discs are played on recorders attached to standard television sets.

4.1.1 Making the Master Disc

The first step is to obtain the source information in the form of NTSC format video (e.g., video camera, video tape, etc.). The master disc is a polished plate glass 0.24 inches thick, 7 inch radius, and is coated with a thin metal film.

The mastering process is shown in Figure 2. The NTSC video source is converted to an FM signal. The VCO has a center frequency of 7 MHz and a deviation of ±1 MHz for a 1 volt peak-to-peak video

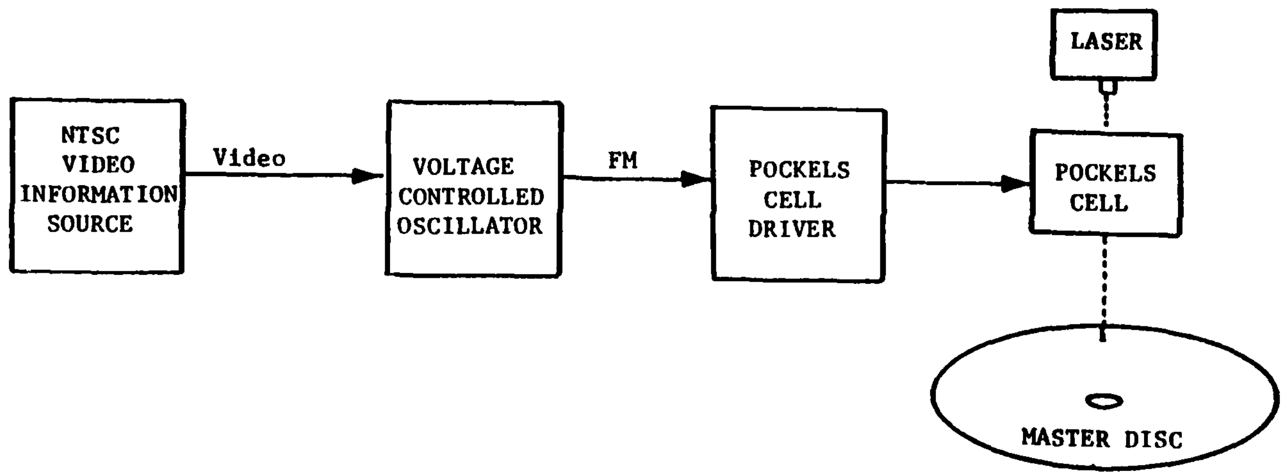

FIGURE 2
MAKING THE MASTER DISC

signal. The VCO's output FM signal is applied to a Pockels cell driver. The driver's output, occupying a spectrum from 2.5 MHz to 11.5 MHz, is applied to a Pockels cell electro-optical modulator. The Pockels cell alternately passes or blocks the laser beam under the influence of the cell driver. When the laser is allowed to pass, the master disc's metal coating is melted producing small pits. The pits are ovals at the extreme radius and are very nearly circular at the inner radius. The program material recording pits appear on the disc in the form of a spiral running from the outer diameter inward with a pitch of 1.66 microns per revolution or 15,000 tracks per radial inch. One TV frame is recorded per revolution.

Within each vertical interval a coded digital frame number (and, if desired, other digital information) is recorded using a self-clocking format to simplify the data recovery process. The DISCO-VISION disc's high-density information storage capability for digital data is about 40 billion bits per disc side. A feature of this mastering technique is that the master may be read while it is being made. This allows recording adjustments to be made and the quality monitored. Production of the master is in real time; i.e., one-half hour of video source (54,000 video frames) requires one-half hour to make the master.

4.1.2 Replication

The master disc is used to make "stamper" discs from which replicas can be made. The replicas are thermoformed from the "stampers" (typically the replicas are made from an acrylic compound) by a method similar to that used to make audio records. The plastic discs have a reflective aluminum coating covered by a transparent plastic coating for protection. The disc is only 0.04 inches thick and 12 inches in diameter and looks similar to an LP record. The cost of the material for a one-half hour disc is about seven cents.

This compares to about $15 for a one-half hour 3/4-inch video tape, or $50 per one-half hour for Super 8mm film. A thin (about 0.01 inch) flexible mylar disc may also be developed.

4.1.3 Playback

Playback is accomplished as shown in Figure 3. This is essentially the reverse of the recording process. An optical system is used to focus a low-power (1 milliwatt) helium-neon laser beam on the small read spots (i.e., pits) in the tracks on the surface of the disc. The optical system also collects the reflected optical energy and directs it to a single photo-detector. The resulting FM signal is converted to NTSC-video which can be played by any standard TV receiver.

The disc is rotated at 30 revolutions per second; hence, the NTSC 30 frames per second (60 fields) is produced. The consumer player is 18" x 18" x 8 1/2" and weighs less than 40 pounds. A player/changer could be designed so that discs could be accessed in any order with disc change time being less than ten seconds. Home consumer players are expected to sell for about $500 to $600 each. The consumer version will feature stereo sound tracks.

A tracking servo controls the radial position of the read beam. A leadscrew drive system moves the read head on a near radial path at the nominal pitch rate. In fast forward or reverse, the leadscrew in consumer players is driven 100 times normal speed until the desired frame number is found. In freeze frame, the read beam is "jumped back" one track after reading a frame to continuously repeat it. In the current experimental industrial models, access to any frame is also about 15 seconds but MCA indicates this time could be reduced to one second if a larger motor is used to drive the leadscrew. In

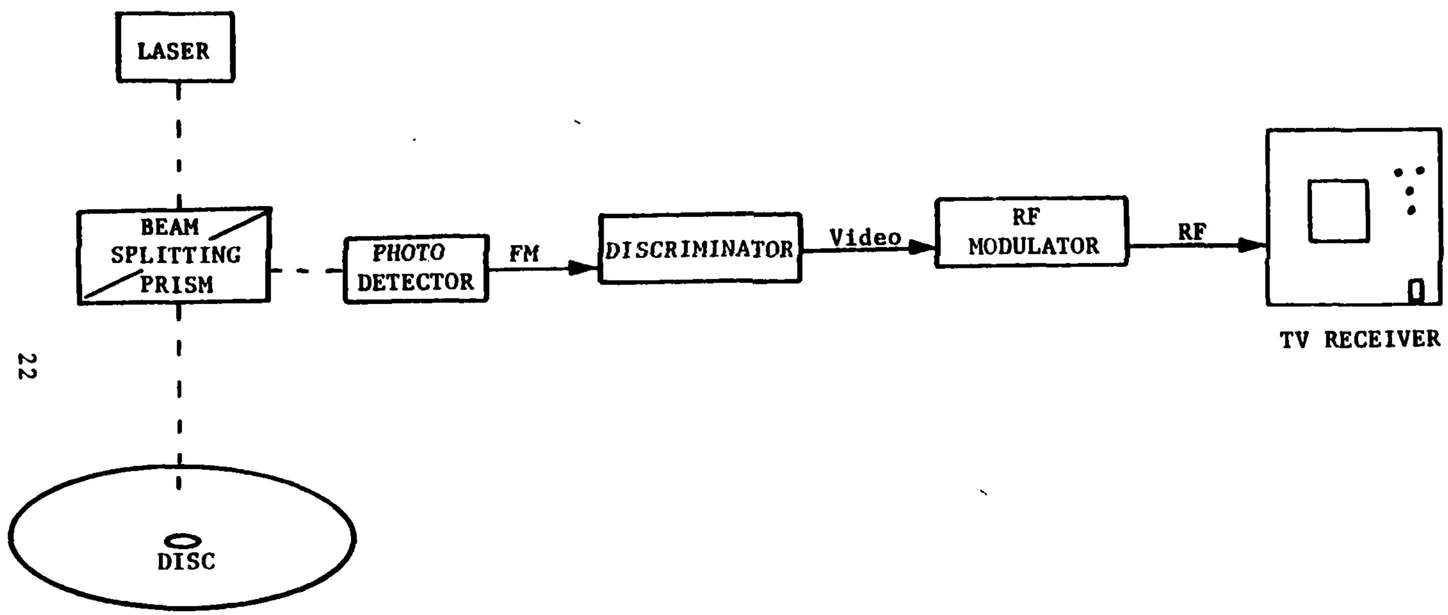

FIGURE 3
PLAYING VIDEO DISC

the current industrial version, the read mechanism remains fixed and the turntable is moved by the leadscrew.

The aerodynamic reading head never touches the disc. The thin video disc is separated from the turntable by a film of air when the turntable is rotating at speed. The laser's expected useful life is 20,000 hours. It can be replaced simply, quickly, and inexpensively (expected to be in the order of about $20).

In addition to the 525 line American standard NTSC system, the European PAL 625 line, and the French 819 line systems will be produced for consumers (probably by Philips). It is likely that eventually the industrial/professional system will be produced in a 1023 line format. This can be accomplished by using two revolutions to record a TV frame instead of one.

4.2 The I/O Metrics VIDEOFILM System

In the I/O Metrics VIDEOFILM System, information is recorded on a 12-inch diameter film disc by modulating a low power He Ne laser. Conceptually the recording process is similar to that described for the MCA system in Paragraph 4.1. The I/O Metrics VIDEOFILM System records on standard Kodak film with emulsions with a resolution exceeding 1,000 line pairs per millimeter. The source signals may be AM, FM, or digital with frequencies from 0 to 10 megacycles.

Disc capacity is 30 minutes of live video, 54,000 still frame images, or 10 billion bits of digital data (theoretical limit 40 billion bits). The time required to process the master film disc <u>after</u> real-time recording of the analog video signal is about 10 minutes; i.e., master disc is ready to play within 10 minutes after recording information. Obviously, in the I/O Metrics System the film cannot be read during the recording process.

An incoherent light source (e.g., white light bulb) is currently used during playback to illuminate a portion of the disc and then the information is recovered electronically. Alternatively a laser could be used for playback. The master disc life is estimated to be in excess of 100 years.

Copies of the master disc can be made by contact copy onto another silver halide film using a collimated light source, or by Diazo replication. Up to 2,000 copies per hour can be produced from a single master using a Diazo replicator. A desk top type Diazo replicator can make 2 copies per minute. I/O Metrics has indicated that a computer disc drive (potentially with multiple heads) will be modified for the industrial version of their player. Movement of the optic head mechanism will be considerably slowed down and access times to any specific frame of about one second (maximum) or in the order of 1/4 to 1/2 second (average) are expected.

5.0 THREE-DIMENSIONAL BATTLEFIELD DISPLAY

The requirements for a three-dimensional (3-D) battlefield display system include the following:

a. The display should provide a 3-D terrain view.

b. The screen size should be about 4' x 4' for general viewing by the Tactical Operation Center (TOC) personnel.

c. Image selection for display should be under operator or computer control and any of thousands of scenes should be retrieved and displayed rapidly (within seconds).

d. There must be a means of superimposing target symbols derived from various sensors (for example, a target acquired and located by a system such as the Stand-Off Target Acquisition System (SOTAS) could be superimposed at the appropriate place on the display).

Relative to item d. above, a major problem exists if the target symbol size is grossly exaggerated with respect to the display scale.

One purpose of the display is to provide information accurate enough for fire direction control. MITRE paper M76-33* identifies a 3-D terrain display for the fire power target teams. Three-dimensional terrain displays are useful in reducing the probable sensor errors by studying the terrain for probable enemy siting locations (e.g., for radars). They could also be useful for planning helicopter free-fire missions.

Seven approaches were examined by the Army Topographic Developments Laboratory (see Reference 2) and the Direct TV Projection techniques were judged most satisfactory for meeting the 3-D display requirements. To eliminate system complexity (interior, relative, and absolute orientation), an orthophoto and its stereomate were selected as the photographic input and the double projection method

*The MITRE Corporation, A Concept for the Corps Operation Command Complex in the 1980s, M76-33, W. A. Tidwell, Washington Operations, July 1976.

was preferred over the single projection method. Two visualization methods were considered, Anaglyphic and Polaroid.

5.1 Anaglyphic Visualization

In Anaglyphic visualization using double projection, the orthophoto and its mate are projected independently through complementary color filters upon a single screen. The resulting imagery is then viewed through spectacles with a blue-green filter for one eye and a red filter for the other eye. The resulting image is a black and white spatial scene that has been formed mentally by observation of the two different optical impressions.

5.2 Polaroid Visualization

In Polaroid visualization using the double projection method, the orthophoto and its mate are individually projected through polarizers (with the polarization axes 90° apart) onto a screen. The resulting imagery is then viewed through corresponding Polaroid spectacles to perceive the effect of a 3-D scene.

5.3 Alternative Implementations of 3-D Displays

A brief survey, indicated three different promising implementations to the 3-D display. They are:

a. Multi-Projection Systems Approach.

b. Single Projection System Approach.

c. Three-Dimensional Television Using Electro-Optic Viewers Approach.

Each of these approaches is described in the following paragraphs.

5.3.1 Multi-Projection Systems Used for 3-D Display

The Army Topographic Laboratory report lists both advantages and disadvantages of direct projection orthophoto display systems. The

report concludes that a modified version of a commercially available color projection television system (i.e., Advent Video Beam, Aeronutronic Ford's ATP-1000, etc.) appears capable of meeting most of the requirements of the 3-D Battlefield Display System. Two TV projectors, each consisting of a high-intensity CRT and associated optics, could be used to project the stereo images onto a screen for viewing through Anaglyphic or Polaroid spectacles. Display of targets, troop units, etc. could be provided by a video projector which would project the computer generated symbols onto the terrain display.

The Army Topographic Laboratory report suggests that conceivably the stereo images could be stored on video tapes. Scaling of symbols and access of other reference data (e.g., elevations, grid coordinates, etc.) by the computer are also mentioned. Also the report indicates a zoom capability is needed, i.e., selection of display scale.

5.3.2 Single Projector 3-D Display System

At the 22 October 1976 technical conference of the Society of Motion Picture and Television Engineers in New York City, Mr. Bruce Stephens of Stephens and Associates demonstrated a wide-screen 3-D video projection system (see References 24, 25, 26, and 27). In this technique, the stereo scene pair are recorded on a single video frame, one occupying the upper half of the frame and the other occupying the lower half of the frame. The stereo images were simultaneously projected (by the General Electric Light Valve) through a polarizer (The Mark's Polarized Corporation's Polarator) and re-directed at the screen so that the stereo images are superimposed and properly polarized. Polaroid spectacles were used by the audience.

5.3.3 Three-Dimensional Television Sets

Mr. Stephens also demonstrated a 3-D video program using a standard television set--at the Cable Arts Foundation in September, 1975 (see Reference 24). In this technique, the stereo views (obtained from video tape) were alternately presented sequentially at the video field scan rate (60 fields per second). The observer wore electro-optic viewers (patented by Dr. John Roese of the Naval Undersea Center and manufactured under contract by Honeywell) to block and unblock each eye alternately in synchronization with the appropriate view being displayed at the instant.

5.4 Operational Steps in Achieving the 3-D Battlefield Display

The steps in the overall process are shown in Figure 4. Each of these steps will be discussed in the following paragraphs.

5.4.1 Make Terrain Photos

The first step is to obtain terrain photographs (orthophotos and their mates). The data base currently being produced for the APPS may be suitable for this purpose. Optical systems with resolutions of 200 line pairs per millimeter are available for this purpose. When optical resolution is specified only line pairs are counted. Note also that TV lines refer to the number of lines per frame and optical resolution is given in lines per millimeter. As a general rule in any information process, the cost of collecting, processing, and organizing information is much more expensive than storing, retrieving, and displaying the information. Yet, the user is often most impacted and frustrated by poor retrieval, and display of the information.

5.4.2 Develop Film

The next step in the process is to develop the film; i.e., the orthophotos and their mates.

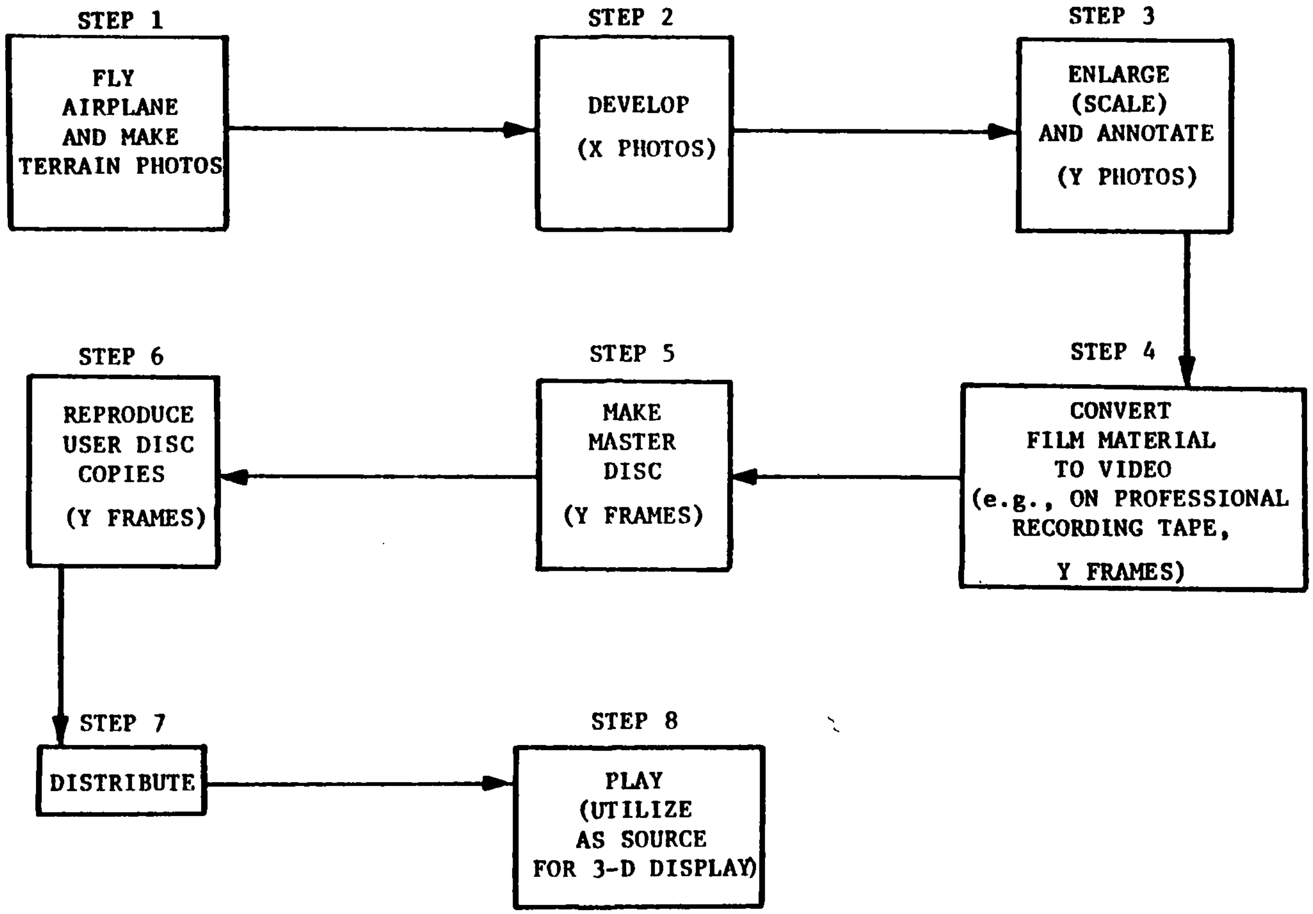

FIGURE 4
STEPS IN 3-D BATTLEFIELD DISPLAY

5.4.3 Enlarge and Annotate Photos

While the optical systems have resolution capabilities of 200 or more line pairs per millimeter, the unaided human eye's acuity is only a few lines per millimeter. Hence, significant magnification is necessary if all of the information recorded by the photographic system is to be observed by the unaided human eye. Since some resolution will be lost in the next step when the film images are converted to television images, some additional magnification should be provided.

Figure 5 illustrates how one APPS photo (the orthophoto or its mate) may be magnified for manual use with the unaided eye or for use on TV. Table VIII illustrates scaling and the ultimate number of video disc required to cover an area of interest as shown in Figure 6. In Table VIII, a 1,000 line TV system is assumed. Each disc will then only accommodate 27,000 frames. The figures in Table VIII apply individually to the orthophoto and its mate. For example, 10.42 disc sides would be required for the 25 cm per TV line (i.e., 0.33 by 0.25 km) scale. Annotations such as military grid lines and reference points would be added to the enlarged images.

5.4.4 Convert Film Material to Video

The next step is to convert the source material to video. For example, the film could be fed directly into the DISCO-VISION mastering machine from a film chain, or it could be transferred to professional magnetic video tape which is then played into the mastering unit.

5.4.5 Make Master Disc for Orthophotos and their Mates

When the orthophotos and their mates are in video form, one master can be made for the orthophotos and another master made for their corresponding mates (assumes multi-projection systems approach). Each frame has a unique identifying number assigned during the mastering

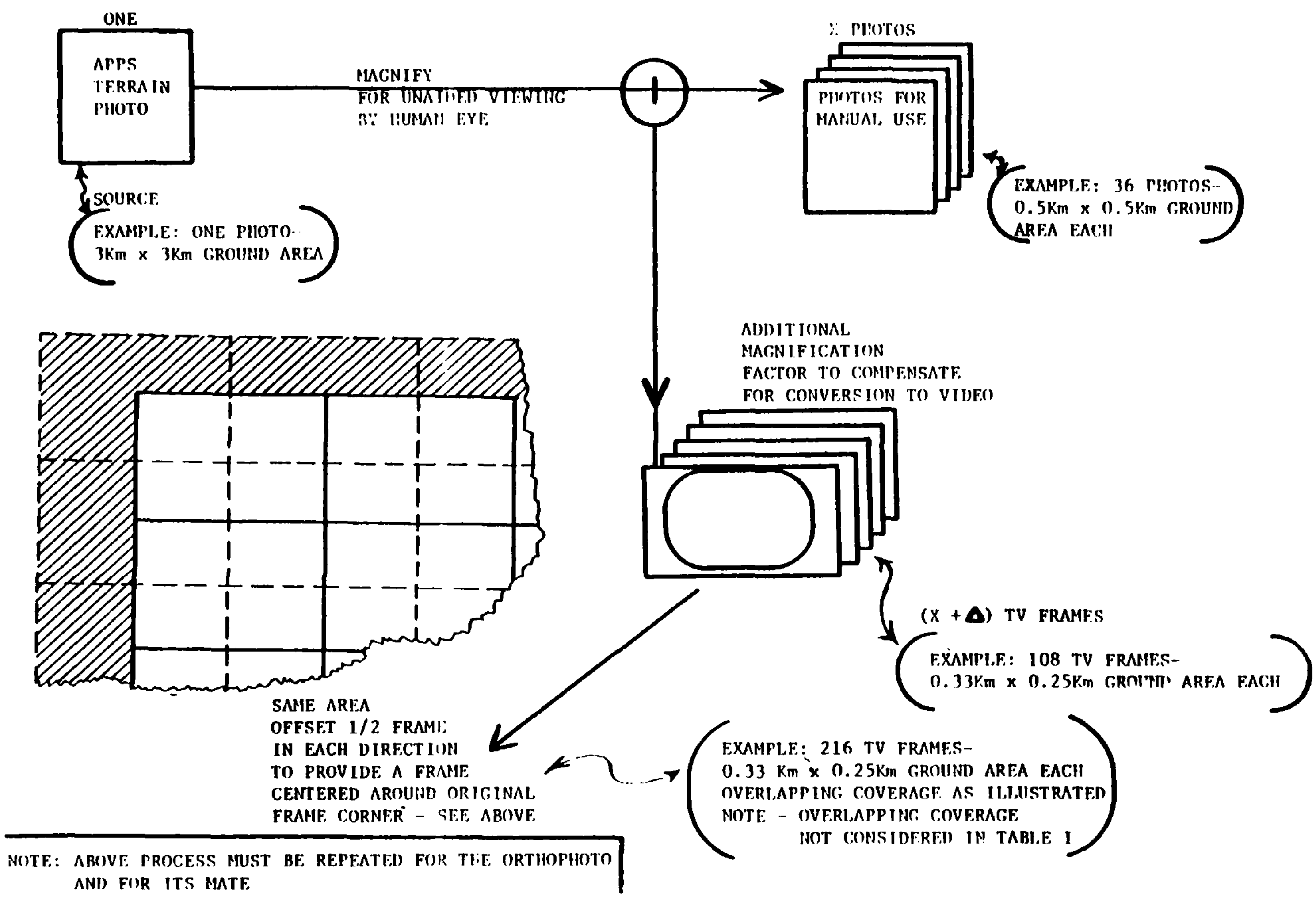

FIGURE 5
ILLUSTRATION OF MAGNIFICATION OF SOURCE PHOTO

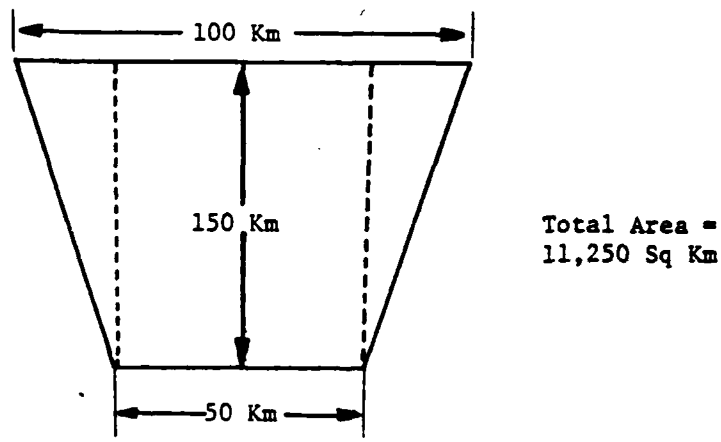

FIGURE 6
AREA OF INTEREST

TABLE VIII

SCALE VS. DISC REQUIREMENTS

SCALE DISTANCE BETWEEN INDIVIDUAL TV LINES	DISPLAY DIMENSIONS (WIDTH X HEIGHT IN KM)	DISPLAYED AREA (SQ KM) PER FRAME	NUMBER* OF 12" DISC SIDES TO STORE 11,250 SQ KM (1,023 LINES/FRAME)	NUMBER* OF FRAMES REQUIRED
25 cm	0.33 x 0.25	0.08	5.21	140,625
50 cm	0.55 x 0.50	0.33	1.27	34,091
1 meter	1.33 x 1.0	1.33	0.32	8,459
2 meters	2.67 x 2.0	5.33	0.08	2,111
5 meters	6.67 x 5.0	33.33	0.01	338

***NOTE:** Numbers in these columns apply to the orthophotos. Identical numbers also apply to the stereo mates.

Also note that only half as many discs would be required if a 525 lines/frame standard system were used.

process. Each frame on each master would be identified to the computer (e.g., MGR coordinates) so that under the computer's control the two players could be used to simultaneously access and freeze a corresponding orthophoto and its mate. Mastering from the video source can be accomplished at the rate of one disc per half hour.

5.4.6 Replication of User Discs

The two masters would then be used to replicate discs for users. Replication rates as high as one disc every three seconds is possible.

5.5 Three-Dimensional Demonstration

A demonstration of 3-D battlefield display using video disc technology would afford the Army an opportunity to evaluate the operational steps of converting source material to video discs and provide first-hand experience relevant to a number of other military applications. It is suggested that a simple demonstration of this capability would be beneficial. Based on discussions with MCA Inc. and I/O Metric Corporation, some rough estimates have been made of equipment and contractor support costs. These costs do not include any costs associated with structuring and running demonstrations, preparing scenarios, obtaining government furnished equipments and facilities, etc. The demonstration period is envisioned as about six months and could begin by late 1977 or early 1978. The cost estimates are:

a. MCA Costs: $100,000

These costs include:

(1) mastering & replication of ortho and mate terrain demonstration discs.

(2) Lease of Disco-Vision changers, control, and switching equipment.

(3) MCA Engineering Support

b.	Large Screen Display Device Cost	$ 60,000
	Includes General Electric Light Valve or multiple Eidophor EP-8 projectors.	
c.	Miscellaneous Cost	$ 40,000
	Includes Purchase or Lease of Minicomputer and computer disc storage equipment.	
Total contractor Demo Costs		$200,000

6.0 AN AUTOMATED ANALYTICAL PHOTOGRAMMETRIC POSITIONING SYSTEM (APPS) UTILIZING VIDEO DISCS

The APPS is a system that utilizes a point positioning data base in conjunction with reconnaissance imagery to determine precise locations for targeting or map making.

6.1 Description of Current APPS

The APPS depends on having an area that has been metrically photographed so that there are some strips of overlapping photographs. Two or more strips of photography comprise a block. Central to the APPS are the following:

a. Photogrammetrists select and measure common overlapping points between photos (these points are annotated to assist operator alignment for stereo).

b. The ground-surveyed or known geodetic control points are also identified and measured on the photos (these points are annotated and used to check the operator's alignment).

c. This interlocking set of photo measurements and the geodetic control coordinates are processed in a simultaneous least squares solution until the center of the camera lens (X^c, Y^c, Z^c) and the three altitude angles of the film plane (ω, ϕ, κ) are computed for each picture.

d. These six parameters (X^c, Y^c, Z^c, ω, ϕ, κ) are entered on a calculator's tape cassette. The tape cassettes and associated photographs are called a Point Positioning Data Base. When this is associated with a user's APPS equipment, this is often called the APPS data base.

e. The user's equipment consists of a stereo measuring instrument with encoders that send X, Y photo measurements of a stereo image point from two overlapping photographs to a programmable calculator. The calculator computes geographic coordinates--latitude, longitude, and elevation for the point.

Initially, the operator at the user's location selects the appropriate pair of photos and the correct cassette tape from a

folding file. He then aligns the system with the photos using the annotated reference points. The camera lens center (X^c, Y^c, Z^c), a specific point on the APPS photo in the film plane, and the specific point on the ground all fall in a straight line. Thus, for the stereo pair of photos, these lines for the specific point intersect at the ground position. Since the camera lens center coordinates (X^c, Y^c, Z^c) are known, as are the film plane altitudes (ω, ϕ, κ) for each photograph, when a point's X, Y measurements on the stereo image are entered, the calculator (which is preprogrammed) computes the desired point's X, Y, Z coordinates. The calculator also transforms the point's X, Y, Z coordinates to UTM grid coordinates, or to latitude, longitude, and elevation, or Loran TDs and DME coordinates, depending on the user's needs. The time required from the initial receipt of the initial user target positioning request to the derivation of its coordinates is between 8 and 15 minutes for a single well defined feature. Subsequent positional data extracted from the same photos require from one to several minutes each.

In general, the accuracy of APPS is largely a function of flying height and the scale of the photograph constituting the Point Positioning Data Base. Typically, APPS photos are 150,000:1, 100,000:1, or 50,000:1. Accuracy also depends on the operator's ability to identify and measure photo image points. In general, the same factors effect map accuracy; that is, the smaller the map scale, the greater the error. The APPS should be more accurate than a map because the drafting and reproduction process is eliminated.

6.2 Use of Video Discs for the APPS Application

In order to speed the production of APPS target coordinates and to increase accuracy, video discs could be used as described below. This should decrease response times because:

a. Rapid search and retrieval of appropriate APPS photo pairs on video discs under computer control would be provided.

b. Pre-registration and automatic alignment of APPS stereo pairs on video discs would be provided; thereby greatly reducing set up time.

Increased operator accuracy in locating image points may also be realized due to large magnifications of the APPS photos.

The APPS stereo pairs would be recorded on video discs as described in Section 5.0. Projection of images for operator use would be by one of the three techniques described in Paragraphs 5.3.1, 5.3.2, and 5.3.3. During the video discs mastering process, the stereo pairs would be as closely registered as feasible. During replay, the registration could be refined using automatic optical image correlation techniques or the operator could use a computer generated cursor symbol and the APPS reference points, and a set of manual optical alignment controls.

The operator could use the cursor and known geodetic control points to check the system registration. The computer would contain the APPS data base parametric information (e.g., camera lens center, X^c, Y^c, Z^c; film plane attitude, ω, ϕ, κ, etc.) and perform all calculations currently performed by the APPS calculator.

Thus, to use the system, an operator would examine a reconnaissance photo (perhaps live video imagery in near real time). He would then select and enter a scale and an approximate grid location of the target. The computer would then select the appropriate pair of APPS photos for his viewing. The operator may quickly locate the general area of the target by comparing the reconnaissance image with the displayed APPS image. Then, the operator may locate the cursor in general area of target on his APPS display and enter a much larger

display scale. The computer would again select the appropriate stereo pair for this new scale, thus effectively providing a zoom capability. After refinement of display alignment, the operator may now move his cursor to the target point by carefully comparing target location on his reconnaissance imagery and the cursor location. When the operator is satisfied with cursor placement, he will command the computer to calculate and display the target location in the coordinate system of his choice.

The pre-registration of photo pairs on video discs, computer search and retrieval of appropriate photo pairs, faster final registration of the photo pair, and location of the target on a much larger scale image should all help to speed the target coordinate production process. This speed may be important in a target-rich environment like Europe. Also, this speed is important to taking full advantage of near real-time reconnaissance imaging systems.

Improved accuracy should result due to the magnification of APPS photos. This will provide much larger scales and should improve the operator's target fixing on the APPS display. At a scale of 50,000:1, one hundredth of an inch is 41.7 feet. So an operator error of 0.01 inch in locating a target on the APPS at this scale will result in a 41.7 foot error in addition to the APPS system error, about 19.7 feet at this scale. An operator target location error of 0.1 inch on the APPS photos at a 50,000:1 scale results in an error of about 416.7 feet in addition to the 19.7 feet APPS system error. As indicated on Table IX, APPS photos could be magnified to a scale of 500:1 and still require few discs. At a 500:1 scale, a 0.1 inch operator error results in an error of about 4.2 feet which is in addition to the 19.7 feet APPS system error (which may also be reduced by better and more consistent system registration).

TABLE IX

GEOGRAPHIC VIDEO DISCS

(MAPS OR TERRAIN PHOTOS)

DESCRIPTION OF AREA	TOTAL AREA (SQ. MILES)	NUMBER OF DISC REQUIRED* WHEN SINGLE FRAME 4X3 MI.	NUMBER OF DISC REQUIRED** WHEN SINGLE FRAME 0.4X0.3 MI.
CONTINENT OF ASIA	16,988,000	26.2	2,621.6
CONTINENT OF AFRICA	11,506,000	17.8	1,775.6
CONTINENT OF NO. AMERICA	9,390,000	14.5	1,449.1
CONTINENT OF SO. AMERICA	6,795,000	10.5	1,048.6
CONTINENT OF EUROPE	3,745,000	5.8	577.9
CONTINENT OF AUSTRALIA	2,968,000	4.6	460.8
CONTINENT ANTARCTICA	5,500,000	8.5	848.8
WEST GERMANY	95,815	0.15	14.8
EAST GERMANY	40,646	0.06	6.3
EAST & WEST GERMANY	136,461	0.21	21.1
TOTAL LAND MASS OF EARTH	57,530,000	88.8	8,878.1

NOTE:
- 3-D requires double the number of discs shown;
- Assumes 525 lines/frame system.

* 30.2 ft. per line at 525 lines per frame.
** 3 ft. per line at 525 lines per frame.

SCALES:
- Frame 4x3 miles
  - a) Displayed 4x3 ft 5280:1
  - b) Displayed 1x0.75 ft 21,120:1
- Frame 0.4x0.3 miles
  - a) Displayed 4x3 ft 528:1
  - b) Displayed 1x0.75 ft. 2112:1

7.0 MOBILE MILITARY REFERENCE LIBRARY

This paragraph presents a concept for a futuristic mobile military library. Based on currently available products, the size and weight and a possible configuration of such a library is illustrated in Figure 7. This library, with about one cubic foot of video discs, requires just a little less than 14 cubic feet of space and weighs only about 320 pounds.

The components of the library and their function are as follows:

a. Video Player Number Two - Access Library Discs in Discs Storage Area.

b. Discs Storage Area - Holds approximately 300 video discs which can be randomly selected by a juke box type device and loaded on Video Player Number Two.

c. Video Player Number One - Provide digital storage for microcomputer programs and an inverted file of keywords with pointers to discs and frames associated with specific keywords; used to aid users in finding relevant information in video library.

d. Keyboard - Provides user input (e.g., keywords) to microcomputer.

e. Video Display - Provides means of presenting information from both the video library (i.e., output of Video Player Number One) and the microcomputer (alphanumeric information, e.g., keywords and pointers). Remote user displays and keyboards could be provided.

f. Hard Copy Unit - Provides user a means to obtain a hard copy of information displayed on Video Display.

g. Microcomputer - Provides assistance to user in finding relevant material in library by accepting keyword information input via keyboard and searching digital inverted file of keywords and pointing the user to appropriate discs and frames in the video library. A juke box mechanism may be controlled by the microcomputer to automatically select appropriate disc and frame to be presented.

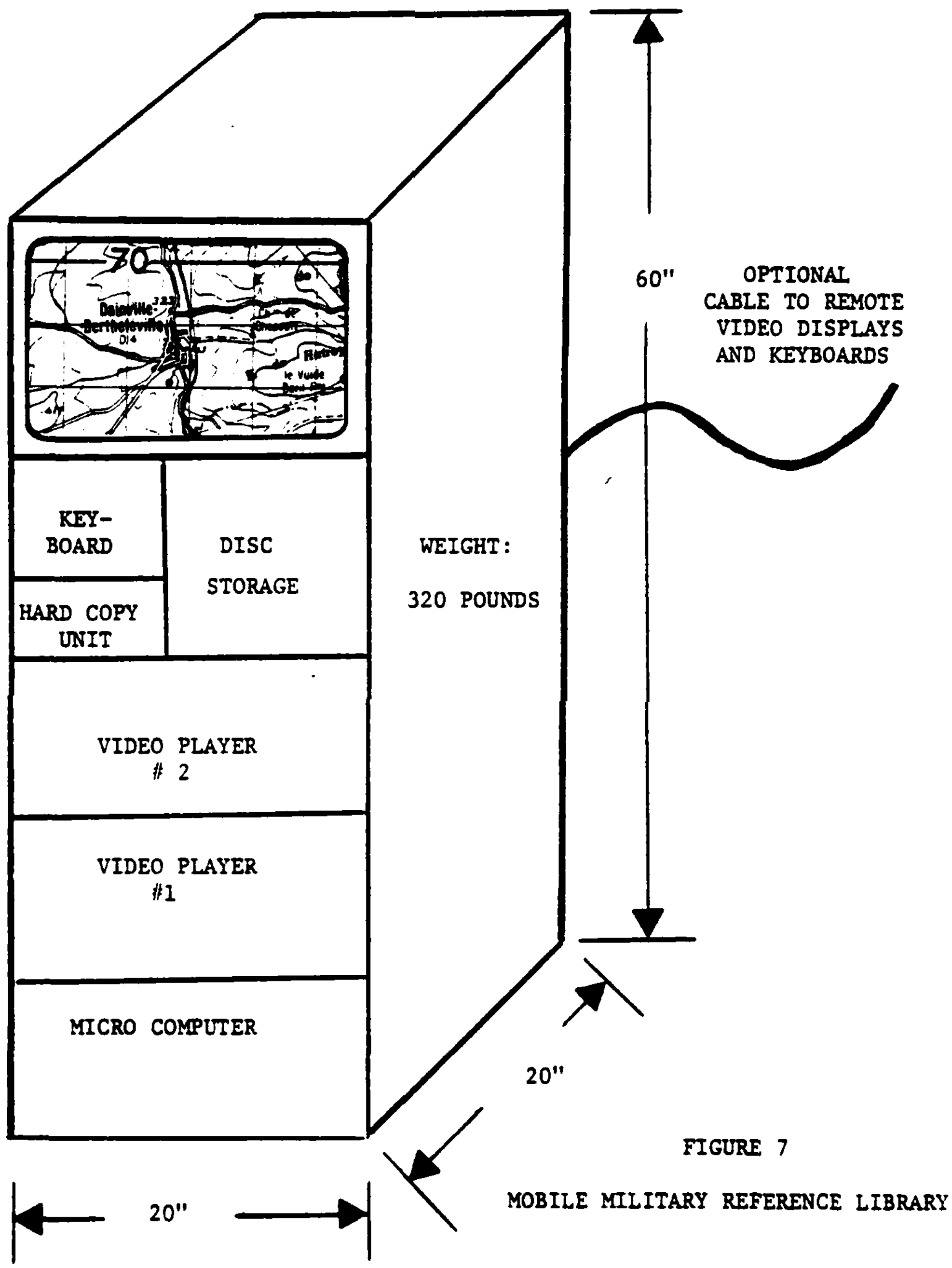

FIGURE 7
MOBILE MILITARY REFERENCE LIBRARY

7.1 Contents of Library

The one cubic foot of discs storage could accommodate 300 one-sided video discs (each 0.04 inches thick and 12" in diameter). Each disc has 54,000 images (or about 18,000 pages of documentation assuming 1/3 page per video image). Thus, the library would contain 16,200,000 images or the equivalent of about 5,400,000 pages of documentation. Assuming 100 pages average per document, this is equivalent to about 54,000 documents.

At a replication cost of 60 cents per copy, the cost of discs (excluding recording and costs of source material) would be about $180. Obviously, other discs could be stored in containers within the user's facility.

The contents of the military library could include:

- Enemy Installation Files (e.g., airfields, ports, hardness, etc.)
- Technical Manuals for Equipments, Parts Lists, Drawings, etc.
- Field Manuals
- Plans
- Terrain Photographs
- Photographs and Personality Profiles of Enemy Leaders
- Photographs of Enemy Weapons Systems with Specifications and Operational Capabilities
- Enemy Order of Battle Reference Information
- Telephone Numbers, Addresses, etc.
- Reporting Requirements and Procedures
- Pictorial and Acoustic Language Translation Dictionaries
- Contingency Orders/Plans

- Inventory/Resupply Information
- Maps
- "How to" Information
- Target List/Priorities
- EW Reference Information
- Situation Templates (providing enemy objectives considering terrain to be compared with current enemy situation)
- Code Books
- Training Films (on video disc) with four NATO languages selectable by user

7.2 Search and Retrieval of Library Information

The user would be able to rapidly determine where information resides in the library (discs and frame numbers) using keywords (e.g., Soviet Tanks) and Boolean connectors (AND, OR, NOT). Video player Number One would contain a disc with a library of programs for the microcomputer and an inverted file of keywords for retrieval of the information. The disc has a capacity of 40 billion bits or about 5 billion bytes of information. This is equivalent to about 25 traditional large-scale computer disc packs.

During creation of master discs, documents would be evaluated (manually or automatically) for keywords reflecting their substance. Assume that for a wide range of military purposes that there are 25,000 keywords of interest. Also assume that for a typical 100 page document, twenty-five keywords reflect the document's substance. Hence, an average of 0.25 keywords per page exist. Thus, for the 5,400,000 page library, there are about 1,350,000 keyword occurrences. Thus, in an inverted file of the twenty-five thousand keywords, each keyword record would contain on the average 54 occurrence pointers.

For example, if a user entered the keyword "Soviet Tanks" he would obtain a list of disc identities with applicable frame numbers which are about this subject. The user may narrow the list by using compound keywords; e.g., "Soviet Tanks" AND "115 mm Weapon." The micro-computer would also process synonyms; for example, the user may enter "gun" instead of "weapon." This inverted keyword pointer approach (much like the index for a book) provides rapid retrieval of source identities which satisfy user request. Obviously, if the above assumptions (quantity of keywords and frequency of occurrence) are valid, only a small portion of the disc capacity would be used. Hence, a keyword "zoom" capability could be made available to help the user decide which reference information is most likely to satisfy his needs.

The inverted keyword file may be created prior to recording by manual review of documents or using an optical character reader (OCR) and an appropriate automated algorithm.

7.3 Viewing Information

Once the user has determined the identity of the source (disc identity and frame number), the appropriate disc is removed from the disc storage and placed on the Video player Number Two. Loading of the disc could be automatic, but for simplicity assume it is manual. The user would then enter the frame number of the image (e.g., page of text, photo, map, etc.) he wishes to view. The player freezes this frame on the video display for his use. The video display serves as both a display for the computer alphanumeric information and for the library information provided by Video player Number Two.

The user can page forward or backward through the document as he desires. Also the hard copy unit may be used to reproduce the image appearing on the video display.

The unit shown in Figure 7 may serve as a central station serving remote users. In this case, remote displays and keyboards would be connected to the central station by cables. Discs loading would be automatic by a "juke box" like mechanism. Magnetic disc frame grabbers (an inexpensive commercial device which records a single frame of television information and freezes it on screen for viewing) in the remote terminals would allow the central station to simultaneously serve several users. A new user could gain access to library material while other users are viewing previously delivered video frames that are stored by their frame grabbers.

7.4 Extracting of Information for Word Processing

An optical character reader could be used in conjunction with the video display to digitize specific text in references of interest for word processing systems. Thus, an electronic cut and paste capability would be available for the 5 million page (or more) library. This would expedite creation of operational documentation without use of massive digital files and the resulting requirements for significant computer resources. Also, the hard copy unit provides a capability to reproduce image information such as terrain photographs, maps, etc. which reside in the library.

7.5 Security

Obviously, some security for information on the disc is provided by the fact that it can only be used on a compatible player. Additionally, physical security can be provided since information can be retrieved only by hard-wired terminals. However, additional security could be provided (even for transmitted visual images) if information recorded on the discs were digitized and encrypted.

7.6 Cost of Components

The cost of the entire basic mobile military library as described based upon vendor product prices would vary from less than $5,000 purchase (using consumer-type products) to over $70,000 lease per year for the heavy-duty experimental industrial quality MCA system.

Cost for recording and replication would be similar to that for the 3-D display discussed in Section 10.0. Obviously, the major cost--of obtaining and processing the source material--is not included in the above prices.

8.0 UPDATING VIDEO DISCS

The most direct technique would be a computer controlled mastering process which employs both the old disc and an updated source (e.g., videotape) containing the revised or new information as input sources and switches between these to produce the new master disc. The computer would use the old disc as input until it reads a frame number where new information is desired; it could then switch to the update source for that frame. This process is equivalent to the common computer tape updating process.

In applications involving computer controlled storage/retrieval of digital data, a different updating process may be advantageous if a satisfactory "one-copy" mastering technique (now under development by MCA) is developed. The current MCA mastering equipment provides a direct read after write (DRAW) capability. Thus, considering the large digital capacity (40 billion bits) of a disc, it may be advantageous in some instances to record the new information "records" directly on black portion of the existing disc and then have the computer "forget" the existence of the "old record" and remember only the location of the updated "new record." Even if the master disc cost several hundred dollars, the capacity of the video disc versus other media (as shown in Table II) could make this method of updating a cost-effective choice.

9.0 MAJOR ISSUES

Many companies (about 20) are actively pursuing or claim active interest in video disc technology. Technological advances are likely to continue at a rapid rate. Most notably, low-cost solid state lasers could result in lower power supply requirements, simpler optical assemblies, and more rugged equipment designs.

Since this technology is new and the equipments are relatively untested, there are a number of open questions and issues in both the technical and operational categories. A number of major issues are cited below; each of these issues represents an aggregation of lower level concerns.

a. Technical Issues:

1. Environmental and user disc handling problems,
2. Verification of disc life,
3. Maintainability of equipments by operational personnel,
4. Reliability of equipments,
5. Existing technical design problems, especially in mastering and replication.

b. Operational Issues:

1. Which system satisfies military user needs best?
2. What applications should the video disc technology be used to satisfy?
3. What source materials need to be converted to video discs? What is the best method to organize material? What is the best method to convert it?
4. Where are mastering and replication facilities needed? What are operational requirements; e.g., Time to record? Time to replicate? Mobility requirements?
5. Is there a need for each service or all of DoD to standardize on a single compatible disc system?

6. What are the appropriate cost/effectiveness tradeoffs for a system; e.g., complex recording and replication versus simple disc or vice versa? Automatic versus manual disc loading, etc.?

The above is not an exhaustive list of issues or questions but should provide an indication of those that need to be considered for this emerging technology.

10.0 COSTS

Operationally, the MCA system requires a facility of 5,000 to 6,000 square feet for the mastering and replication processes. The I/O Metric system would require substantially less space. The video disc equipment costs are summarized for each system below:

a. MCA DISCO-VISION

- Mastering Equipment - $400K per year on 3-year lease
- Replication Equipment - $400K per year on 3-year lease
- Current Experimental Industrial Player (525 lines/frame)* - $30K per year lease; projected to sell for about $7,000 when design is finalized
- Home-Consumer Player - $500 to $600 purchase price (est.)
- Disc Copies** - $0.60 each

b. I/O Metric VIDEOFILM

- Recording Equipment - $45K to $50K purchase price
- Replication Equipment

  1 - two copies/min. - $7,500 purchase price
  2 - two thousand copies/hr. - $35,000 purchase price
- Player - $5K purchase price
- Master Disc*** - $2.50 each - in quantity $.40 each
- Diazo copies*** - $.30 each - in quantity $.10 each

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* It is estimated that a 1,023 lines per frame system would cost 10 to 20% more.

** Excludes Cost of Program Material. Estimate based on run of 10,000 copies.

*** Excludes cost of program material.

The cost of large screen projectors span a large range. However, a color system such as the General Electric Light Valve can be purchased in the $60K range.

11.0 SUMMARY

This technology has potentially great advantages in handling, storage, and retrieval of many types of information. The cost of replicated copies and the user playback equipment are significantly less expensive than other currently available alternative means. Also, the replication rates are far in excess of the other means now available. However, in most cases the cost of collecting the information (e.g., flying reconnaissance missions), preparing the information (e.g., annotating terrain photographs), and other human intensive processes will continue to be the majority of the total information costs. The effectiveness and utility of these devices promises to be very high--if the applications for which they are employed are carefully selected. Accordingly, it is felt that the Army should obtain experience with this technology and its applicability to military problems.

It is expected that video disc technology and equipment capability will experience considerable growth over the next several years as the manufacturers compete for positions--primarily in the home entertainment market and secondarily in military/industrial markets. Accordingly, if the Army chooses to invest R&D funds in this technology, it seems advisable to direct funded efforts at determining and exploiting the potential utility of video discs for military applications rather than at advancing the basic video disc technology. Three types of applications are explored in this report: a 3-D battlefield display; an improvement to the Analytical Photogrammetric Positioning System (APPS); and a mobile military reference library. It is suggested that a demonstration program would serve to gain practical experience with this technology and to acquaint the Army with its potential.

As indicated in Section 5.5, a simple demonstration of the 3-D battlefield display could be developed in a fashion which would incorporate several features of the other two applications discussed in

this report. This demonstration would afford the Army an opportunity to evaluate the operational steps of converting source material to video discs and provide first-hand experience relevant to a number of other military applications. The duration of the experimentation program would be about six months and the cost would be between $100K and $200K. Demonstrations could take place in late 1977 or early 1978.

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